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ABSTRACT

An experiment testing the effectiveness of various types of programed instruction employed the following format variables: (1) hierarchical summaries presented prior to the problems, (2) summary statements presented after and relevant to each missed problem, and (3) step-by-step problem solving procedures presented after and relevant to each missed problem. Seventy-one male college freshmen were divided into aptitude categories on the basis of SCAT math and verbal scores. Subjects in each aptitude category then were randomly assigned to treatment and control conditions by which they were taught imaginary science skills. Receiving the summary prior to the problem did not cause subjects to take significantly more time than when the summary was not presented, but did increase their number of correct responses during learning and on test questions. Receiving the summary statements following incorrect responses did take subjects more time than not receiving this summary, and did not significantly increase correct responses during learning or on the test. The presentation of a step-by-step solution following each incorrect answer took more time but increased the number of correct responses during learning and on the test. (KB)

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Preview vs. Review in Learning an Imaginary Science[1]

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Technical Report No. 9

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Preview vs. Review in Learning an Imaginary Science

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Previous investigations related to the nature of hierarchical tasks (Gagné, et al., 1961, 1962; Merrill, 1965) have not drawn a clear distinction between the hierarchical structure of a task and a hierarchical presentation of the task. A hierarchical structure is revealed by a logical analysis which demonstrates that concepts and principles of the higher levels are combinations, reorganizations, elaborations, and applications of the concepts and principles at the lower levels (Gagné, 1965). A hierarchical presentation results when the lowest level is presented to the learner first, then the next level is presented, etc.

It was demonstrated (Merrill, 1965) that in learning a hierarchically-structured imaginary science Ss (Group V) who received only a summary of each lesson (or level) prior to a correction/review test section performed as well on a retention test three weeks later as Ss who received considerably more detailed program instruction prior to the test section. When total time for learning and retention was considered, Ss in this summary-review condition learned the task in half the time required for the other Ss.

In the previous study (Merrill, 1965) Group V first received a hierarchically-structured set of summary statements which provided the student with every principle of the imaginary science. Then the students were presented test questions. If they missed a question they were presented a general review (GR), which consisted of general summary statements that were relevant to the problem, and they

were required to try the question again. If they missed the question a second time, they were presented a specific review (SR), which worked the problem through step by step but without giving the answer, and they were required to try the question a third time. They received the specific review again and were told to answer the question a third or fourth time or until they got the correct answer (correction) at which time they were presented the next question.

The superior performance of this group in the previous research could have been the result of any one or any combination of these conditions. The purpose of the research reported here[3] was to isolate the effects of these confounded factors. By isolating the effects of these conditions it was possible (1) to compare a hierarchically-organized summary presentation with a problem-oriented presentation of the same material; (2) to compare general review (summary statements of principles) with specific review (step by step presentation of solution) and (3) to compare summary, general review, and specific review with a control condition that includes no informational instruction except the correct answer.

Based on Ausubel (1963) and Gagné (1965) it was hypothesized that (1) Ss who received a hierarchical presentation (summary prior to test section) would make fewer errors during learning and subsequent testing than would Ss who received a problem-oriented presentation of the same task (summary after and related to each question). It was also hypothesized that (2) Ss who were presented a general review or specific review when they made errors would make fewer errors during learning and subsequent testing than would Ss who were given only the correct answer. There is no rationale for making a prediction on the third hypothesis hence this research should answer the question: (3) When Ss make errors do those who receive a general review of the particular point make fewer errors during learning and testing than

[3]This project was supported by ONR contract 3985(04), USOE Title VII Contract Nos. 2-20-003 and 4-20-002 and by the Carnegie Corporation of New York. Appreciation is extended to Leon Swartzendruber for soliciting subjects and supervising the data collection, to Scott Krueger for the computer programing and system supervision, and to the staff of TRL for assisting in the data collection.

those who receive a specific review of the point? A final hypothesis is that (4) high ability Ss will make fewer errors during learning and testing and will take less time to learn than will low ability Ss.

Method

Materials

The task consisted of a programed problem-solving presentation of an imaginary science in which the main line frames presented no informational content but merely posed a question (see Fig. 1). Each of these questions required S to figure out some aspect of a Xenograde System and as a set required the use of every principle of the Science. Each question frame (Q) contained part of a Xenograde data table and asked the S to supply the next entry. For example, in Q3:

K-3

t	inner	outer	blips	blip caused by	S_I D	S_I C	S_{II} D	S_{II} C	S_{III} D	S_{III} C
0	4	0			8	+2	10	+1	5	+1
1	3									
2	2									
3	1									
4	0									

Question 3. When does the first blip occur and which satellite caused it?

8 multiple choice answers were given.

All of the informational presentation was left to the summary-preview of the review frame of which there were two types, the GR and SR.

The Summary (SUM) contained five sets (lessons) of summary statements. Each was a statement of one principle of the science. These statements were arranged in hierarchical order, that is, each succeeding statement was a combination, reorganization, elaboration, or application of previous principles. (This hierarch-

ical structure is presented in Merrill 1964, 1965). The general review (GR) frames consisted of the summary statements for those principles which were necessary to the solution of the problem under consideration. These principles were not arranged in hierarchical order but only in order of relevance to the problem with which they were coupled. One of the summary statements coupled with Question 3 is as follows:

The exact time of the first blip caused by a satellite can be found by dividing the distance at t_n (time just before the blip) by the velocity at t_n. This gives the fraction of the second after t_n that the blip occurred. Adding this fraction to t_n gives the exact moment when the collision took place.

In addition to the above statement the general review frame for Question 3 contained statements concerning satellite motion, blips, velocity, and the constant K.

The specific review (SR) frames consisted of a step by step procedure for solving the problem. Principles were recalled as they were appropriate to the problem. The final solution was never given; it was left for S to figure out. A portion of the specific review frame for question 3 is as follows:

...Remember we find the velocity by multiplying K times the charge. At t_0 the velocities are therefore 6 microns/alphon second for S_I (3 x 2 = 6); 3 microns/alphon second for S_{II} and S_{III} (3 x 1 = 3). The time when S_I will collide with the nucleus can be found by dividing S (the distance of S_I from the nucleus at t_0) by 6 (the velocity of S_I at t_0);...

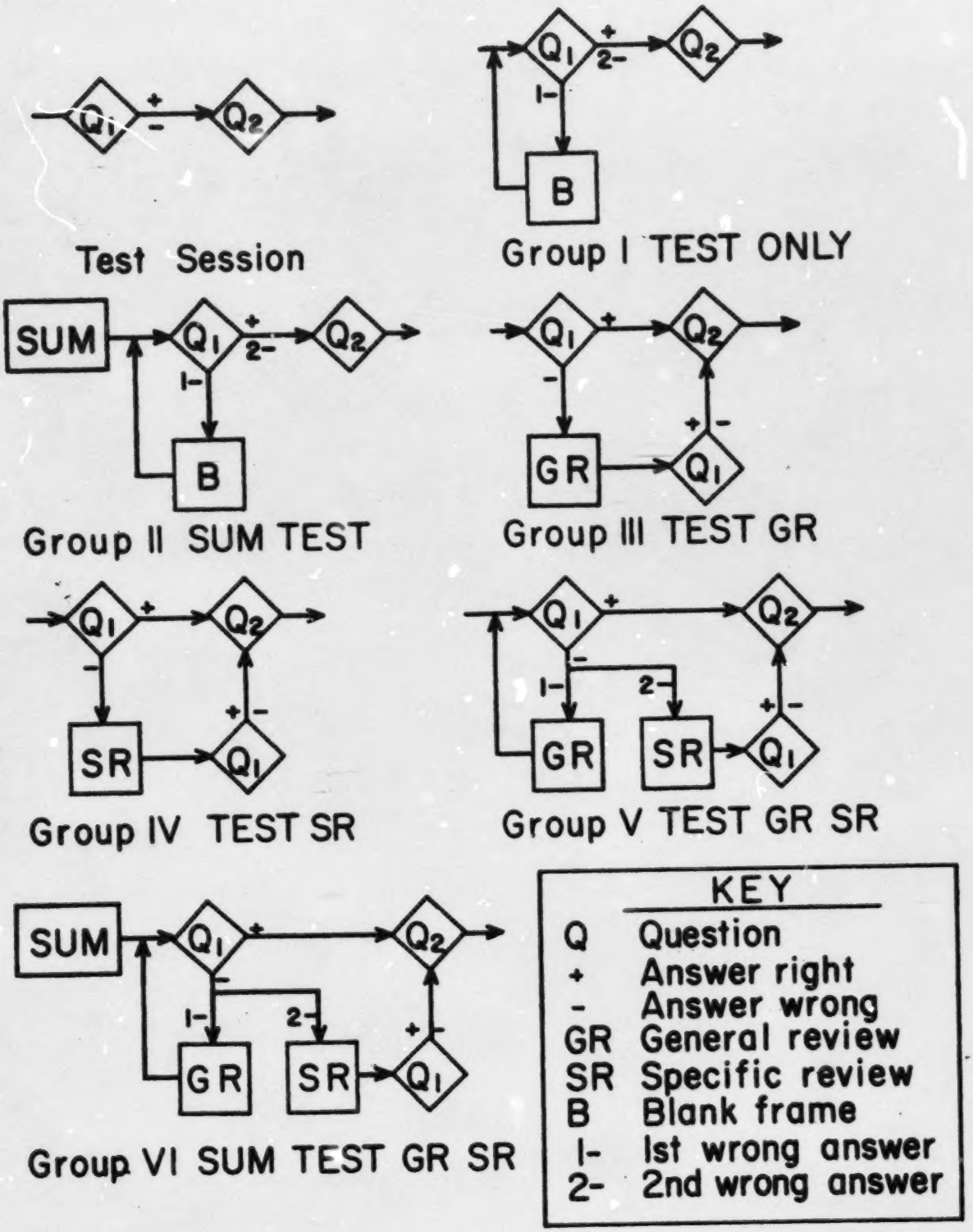

Fig. 1. Flow diagrams for experimental treatments and test.

(The complete set of summary statements and a more detailed discussion of the imaginary science is contained in a previous report[4].

Apparatus

The materials were presented by means of SOCRATES, a computer-based teaching machine using highly modified Autoputor teaching machines as interface units (Stolurow & Davis, 1965; Merrill, 1964).

Subjects

The records of six hundred seventy-five male freshmen were randomly selected from the set entering the College of Liberal Arts, University of Illinois, in one year. Two distributions were plotted for this sample: one based on the verbal scores and one based on the quantitative scores of the School College Abilities Test (SCAT). The verbal distribution was then divided into lower, middle, and upper thirds, and the mean ($\bar{X}_v$) of each third computed. The quantitative distribution was divided into lower and upper halves, and the mean ($\bar{X}_q$) of each half computed. These two distributions (verbal and quantitative) were then combined into a single 3 x 2 bivariate distribution. The verbal and quantitative means were determined for each cell of this distribution. In order to select Ss who were closest to both of these means in each cell, a deviation score was calculated for each S as follows:

$$Pi = (\bar{X}_v - X_{vi})^2 + (\bar{X}_q - X_{qi})^2$$

These Pi scores were ranked and Ss in each cell were mailed letters in order of preference asking them to participate in the experiment. About half of the Ss who received letters responded. In each aptitude category those that responded were randomly assigned to one of the six experimental conditions. As it became

[4] Microfilm copies of the entire program as used in this study and the previous study (Merrill, 1965) are on deposit in the University of Illinois Library, titled "Xenograde System: an imaginary science" by M. David Merrill, 1964.

necessary more letters were mailed until each cell of the experimental design contained two Ss (see Fig. 2). When Ss failed to return to complete the experiment, the next S in the list was solicited to fill his place. Twenty Ss completed the learning session and failed to return for the testing session. The number of Ss in each group who failed to return were as follows: 3, 2, 2, 3, 6, 4. These Ss were excluded from the analysis. A total of 71 Ss participated in the experiment. One S was given double weight in the analysis (see Table 1).

Procedure

The experiment consisted of a single learning session (from 30 min. to 3 hours in length) followed one week later by a test session. The test session was the same for all groups and consisted of 68 questions which required the application of the concepts and principles of the science for their solution. Ss were shown the correct answer to the question when they were presented the next question.

The design of the study indicating each treatment and each aptitude level is illustrated in Fig. 2. Ss within each of the six aptitude categories were randomly assigned to one of six learning conditions. Each of these conditions involved answering the same questions as later used in the test session but accompanied by some supplementary form of instruction which was displayed when, and only when, the incorrect answer was chosen (see Fig. 1). Ss in Group I (test only) were given only the questions (Q) as they were presented in the test session except that when they made an error they were shown a blank frame (B) and then returned for another try at the question. After the second try, they were presented the next question whether or not their second response was correct.

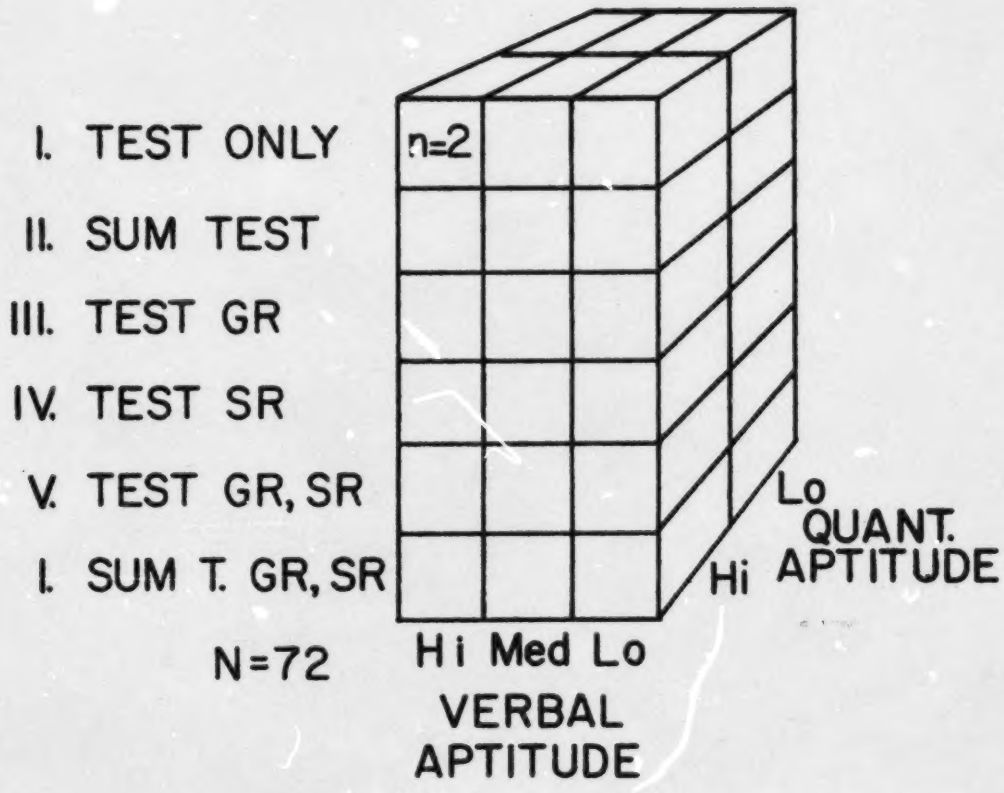

Fig. 2. Experimental design.

This is a modified correction procedure. They were not given any other instruction than the correct answer when they were presented the next question. This group represents a control condition. Ss in Group II (summary test) were presented the five sets of summary statements, and then they were presented the questions in the same way as Group I. Thus they saw all the summary statements and then the questions. The presentation of the summary was hierarchical in nature (see materials section of this report). Ss in Group III (test-GR, general review) were presented each of the statements from this summary as relevant to the question they missed and allowed to answer again when they made an error. Ss in Group IV (test-SR, specific review) were shown how to work the problem step by step when they answered a question incorrectly and they were allowed to answer the question again when they made a second error. Ss in Group V (test-GR-SR) were shown the general review statements after the first error on a question and the step by step solution after their second error. They could receive as many as three tries on a question. On the third try they went on to the next P-frame. Groups I-IV were allowed only two tries on each question. Group VI (summary-test-GR-SR) was the same as Group V except that they were given the summary in the same way as Group II before they answered the test question.

Results

The results of three-way analyses of variance for total time (learning and testing sessions combined), time per question frame during learning, number correct on the first try of the question frames during learning, time per question frame during testing, and number correct during testing are shown in Table 1. The effect associated with treatments for total time, the number of correct responses during learning, and the number of correct responses during testing

Table 1

Analyses of Variance

Variable	df	Total Time		Learning Session				Test Session			
				Time/Frame		1st Try	No. Correct	Time/Frame		No. Correct	
		MS#	F	MS	F	MS	F	MS	F	MS	F
Treatments	5	70.59	4.07**	504.6	0.36	476.6	8.99**	242.2	1.17	649.0	3.83**
Orthogonal Comparison Summary (1 & 5 vs 2 & 3)	1	45.53	2.62			379.7	7.16*			918.8	5.42
GR (1 & 3 vs 4 & 5)	1	73.74	4.25*			30.1	0.57			140.1	0.83
SR (1 & 4 vs 3 & 5)	1	79.88	4.60*			384.1	16.68**			1496.3	8.83**
Other	2	76.90				544.6				344.9	1.66
Verbal	2	29.31	1.69	346.0	0.31	11.0	0.21	162.0	.78	301.5	1.78
Quantitative	1	36.85	2.12	494.0	0.35	91.0	1.72	583.0	2.81	325.0	1.92
T X V	10	21.15	1.22	1262.3	1.14	63.5	1.20	128.4	0.61	75.5	0.45
T X Q	5	18.53	1.07	1350.6	1.22	34.0	.64	279.4	1.35	21.6	0.13
Q X V	2	30.00	1.73	1441.5	1.30	26.5	.50	59.5	0.29	102.5	0.61
T X Q X V	10	14.74	0.85	837.4	.76	76.5	1.44	230.5	1.11	100.1	0.59
Errors##	35	17.36		1106.6		53.0		207.5		169.4	

#Actual MS for Total Time = reported MS x 10^6

##There was only one S in the Low-Low Group VI cell instead of two. This person's score was used twice in the analysis and error df reduced from 36 to 35.

*$p < .05$.

**$p < .01$.

as the dependent variables were all significant at the .01 level. None of the aptitude effects was significant indicating that we could detect no difference in ability to learn this task between persons with high verbal-high mathematical aptitude, persons with low verbal-low mathematical aptitude, and each of the four other combinations of these two variables.

The treatments can be cross classified into two 2 x 2 designs. One has GR-No GR as one dimension and SR-No SR as the other dimension. The other has Summary-No Summary as one dimension and both types of review-no review as the other dimension. It will be observed that these two designs are not independent. However, it is possible to make three meaningful orthogonal comparisons which allow us to look at three main effects: Summary vs. No Summary (Groups I and V vs. II and VI), General Review vs. No General Review (Groups I and III vs. IV and V), and Specific Review vs. No Specific Review (Groups I and IV vs. III and V). These comparisons are also reported in Table 1. The means are illustrated in Fig. 3 and reported with standard deviations in Table 2.

From these comparisons the following relationships can be observed: (1) Being presented the summary as a preview prior to receiving the test items does not take significantly more time than when the summary is not presented, but it does increase the number of correct responses during the learning session and on the test. (2) Being presented a general review (the summary statements specific to and following the questions) does take more time than not receiving a general review, but does not, however, increase the number of correct responses during learning or on the test. (3) Being presented a specific review (being shown the solution to the problem step by step) does take more time than not

Table 2

Means and Standard Deviations for Each Group

on the Variables Indicated

Group	Total* Time		Learning				Testing			
			Time# Frame		No. Correct 1st Try		Time# Frame		No. Correct	
	M	SD	M	SD	M	SD	M	SD	M	SD
I	1.80	.57	51.87	20.78	18.17	5.98	26.00	9.85	23.58	11.73
II	2.38	.91	59.08	31.11	23.67	6.47	32.42	15.64	35.25	10.77
III	3.03	2.45	60.68	35.28	17.33	7.83	35.75	14.76	27.59	9.41
IV	3.06	1.56	70.57	52.93	24.33	8.40	33.67	14.19	35.33	15.18
V	3.20	.70	56.53	18.13	28.33	9.00	33.58	7.31	38.17	9.02
VI	3.71	1.47	64.54	24.77	34.00	9.88	39.33	20.40	44.00	13.14

#Time in seconds.

*Time in hours.

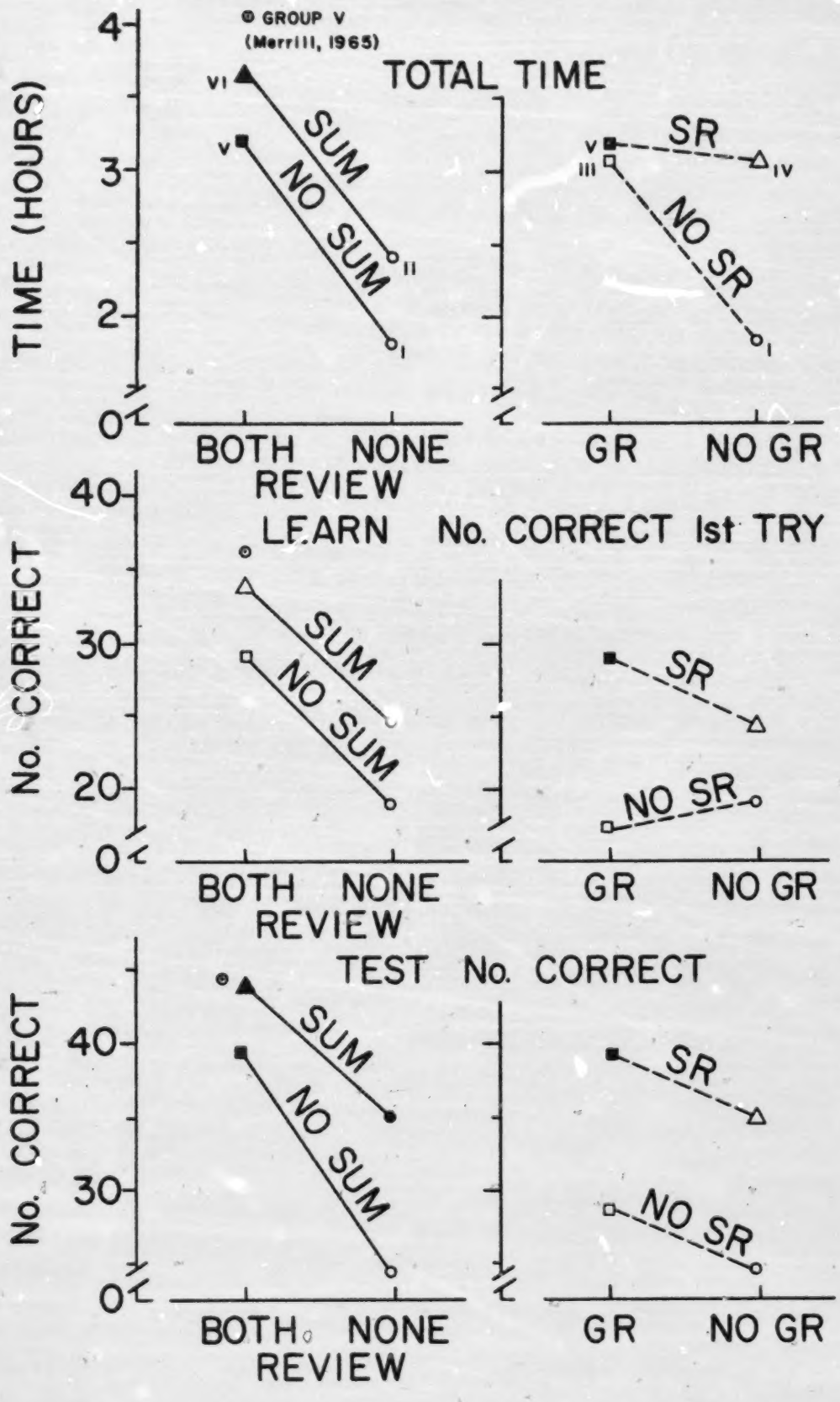

Fig. 3. Comparison of time and error scores for different treatment groups.

receiving a specific review, but it also increases the number of correct responses during learning and on the test.

Discussion

The results of this experiment support hypothesis 1. Ss who received a hierarchical presentation of summary statements prior to the problems did make fewer errors during learning and subsequent testing than did Ss who received a problem-oriented presentation of summary statements. Part of hypothesis 2 was not supported in that when summary statements were used in a question-relevant review (general review) the performance was no better than when no instruction other than the correct answer was given. Both of these findings lend support to Ausubel's (1963) recommendation for the use of advance organizers and to Gagné's (1965) assumption that hierarchical tasks should be presented level by level.

Part of hypothesis 2 was supported in that specific review was more effective than the control condition when no instruction other than the correct answer was given. The answer to Question 3 also seems to be that a specific review is more effective than a presentation of principles. In a problem solving task S apparently finds detailed step by step instruction at applying the principles more useful than a restatement of principles. Note, however, that these same statements of principles facilitate performance when organized and presented in a hierarchical manner prior to the problems. This finding should have implications for the type of informational feedback teachers use in classrooms.

The final hypothesis was not supported. For this task differences in verbal and quantitative aptitude did not make a significant difference in the speed with which the task was learned nor in the performance during learning and testing. Further, it appears that the treatments which produced differences in performance (presentation of summary and use of specific review) were equally effective for both high and low ability Ss. Since the task was very mathematical in nature this is a surprising and rather unusual finding. It is especially interesting to note that some of the low-low Ss who participated in this study dropped out of school the second semester but on this task their performance was not significantly different from high-high Ss.

It is possible to draw some tentative conclusions about the relative efficiency of the various conditions investigated. When Ss are presented a summary prior to receiving the test items (Group II) they do not take significantly more time than when no summary is presented (Group I). However, when Ss are presented a summary prior to receiving the test items (Group II) they do make significantly fewer errors both during learning and testing than when no summary is presented (Group I). When Ss are presented the summary statements in a general review position (Group III) they do take significantly more time than when the summary is presented prior to the test items (Group II) and they do make significantly more errors. Also, Ss who receive the summary prior condition (Group II) take significantly less time than Ss who receive the specific review (Group IV). Hence, using as a criterion the minimum number of errors during testing resulting from the minimum total time to learn, the summary prior condition seems to represent the most efficient instructional

procedure. This again supports the advance organizer notion of Ausubel (1963) and the value of a hierarchical presentation of a hierarchical task advocated by Gagné (1965).

It is possible that a combination procedure might be more efficient than any procedure used alone. Note that Ss who received all conditions, summary prior, test, general and specific review (Group VI) did make the fewest number of errors. This group, however, also took the greatest amount of time to learn. Since they were required to receive the general review first and since the general review was demonstrated to be an ineffective technique, then it is possible that the efficiency of this group was cut down by the inclusion of the general review. Also note that Ss in this group did not make significantly fewer errors than Ss who received all of the conditions except the prior summary (Group V). Both Group V and VI, however, made fewer errors than Ss who received the summary only procedure (Group II) or the specific review procedure (Group IV). It is tempting to conclude that the combination of both reviews improved performance and that the facilitating effect of the summary prior to the test is washed out by the combination review procedure, but this conclusion is not warranted because Ss in both of the combination groups also received an additional try on any question which gave them difficulty. It is probably more likely that the decrease in errors resulted from this additional practice. If the increase in performance is a result of additional practice then the summary only condition (Group II) still represents the most efficient procedure. It is unfortunate that the experimenters did not have the foresight to include a summary-specific review group. It is possible that future research will demonstrate this condition to be the most efficient combination of the procedures investigated.

Summary

Seventy-one Ss were divided into six aptitude combinations on verbal and quantitative SCAT scores and Ss in each condition were randomly assigned to six treatment conditions. The independent variables investigated were a hierarchical summary presented prior to problems, summary statements presented after and relevant to each problem, and step by step procedure for solving problems presented after and relevant to each problem.

The results were as follows: (1) Being presented the summary prior to receiving the problems does not take significantly more time than when the summary is not presented, but it does increase the number of correct responses during the learning session and on the test. (2) Being presented the summary statements specific to and following each incorrect answer does take more time than not receiving this review, but does not, however, significantly increase the number of correct responses during learning or on the test. (3) Being presented a step by step solution following each incorrect answer does take more time than not receiving this review, but it also increases the number of correct responses during learning and on the test.

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